Project Report: Image Filtering and Noise Analysis

The primary goal of this project was to investigate noise added techniques like salt & pepper and random impulse noise. Additionally, evaluated various image filtering techniques (DRID and Median Filtering) and their effectiveness in reducing noise while maintaining image quality.
I evaluated the clean images, analyzed them by comparing them with the noisy image and filtered images. The study aimed to identify the best approaches for improving image clarity, particularly in the presence of random impulse noise and salt & pepper.
The project also explored the calculation of image quality metrics, specifically the Root Mean Square Error (RMSE) and Peak Signal-to-Noise Ratio (PSNR), to quantitatively assess the performance of various filters (Mean, Smart, Spatial Domain).

The project began by establishing functions to calculate RMSE and PSNR. RMSE quantifies the average difference between pixel values of the original (clean) image and the processed image, while PSNR offers a logarithmic measure of the peak error. These metrics provide a comprehensive view of image quality, allowing for effective comparisons.

In the first run, the comparison between the clean image and salt & pepper noise was tested in both corruption rates 0.05 & 1.

Image output analysis with corruption rate of 0.05 (rmse 30.31%, psnr 18.5 dB)

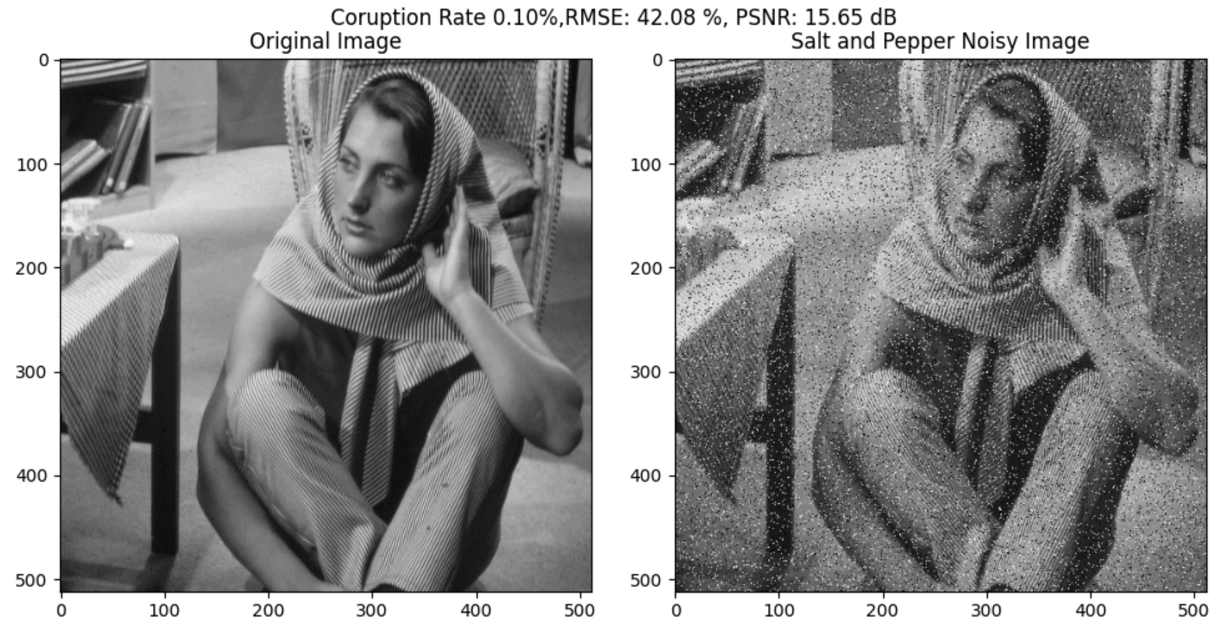


Image output analysis with corruption rate of 0.1 (rmse 42.08%, psnr 15.65 dB)

In the first run, the comparison between the clean image and random impulse noise was tested in both corruption rates 0.05 & 1.

Image output analysis with corruption rate of 0.05 (rmse 19.73%, psnr 22.23 dB)

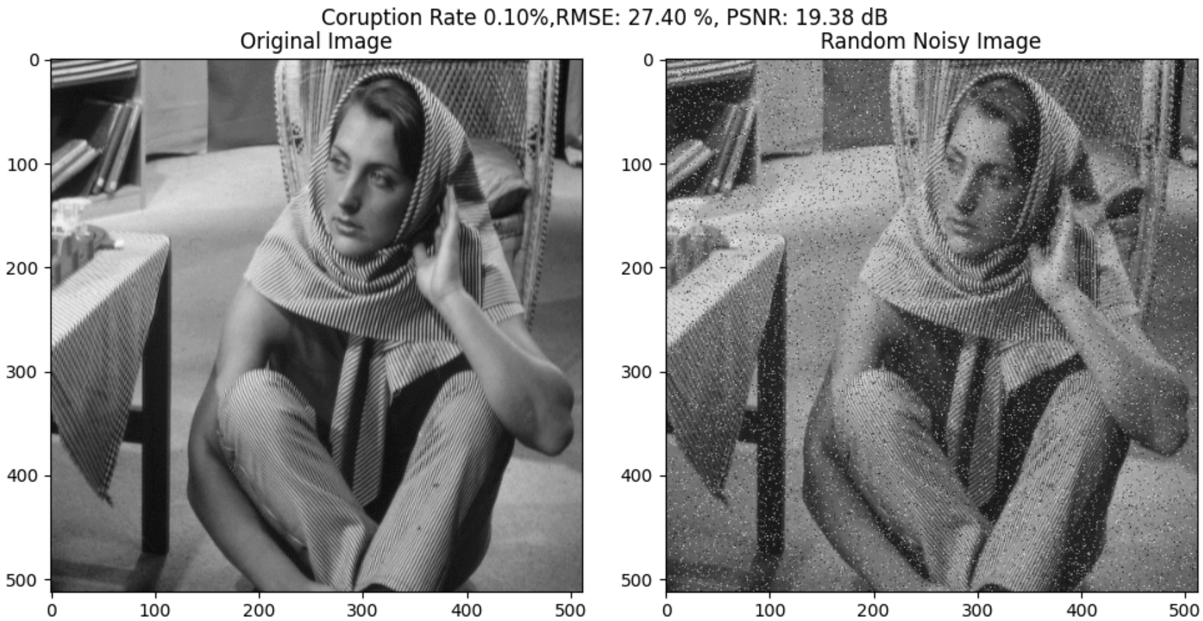


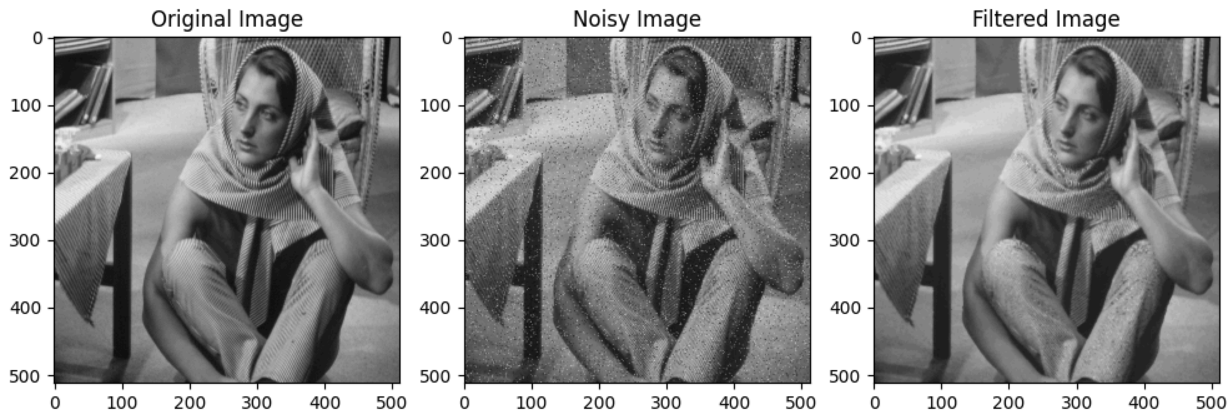
Image output analysis with corruption rate of 0.1 (rmse 27.40%, psnr 19.38 dB)

In this section (question 2c) I evaluated the differential rank impulse detector filter to noisy images and clean images. The goal is to remove noise effectively by applying our custom-designed filtering function, as outlined in part 1b of this report. This approach involves filtering and experimenting with different parameter values for intervals r and s to achieve the most optimal image quality in terms of Root Mean Square Error (RMSE) and Peak Signal-to-Noise Ratio (PSNR).

The filtering process was applied to each noisy image individually, with initial values for r and s set based on previous experiments. For each test, the function was applied multiple times to observe any improvement in image quality and to determine whether further iterations would yield a diminishing return in noise reduction. I evaluated both r=2 s=10 and r=3 and s=10, r=4 and s=10. Of those three evaluations r=2 s=10 performed the best. Higher PSNR indicates better image quality, with less noise and lower RMSE values indicate closer resemblance to the original image.

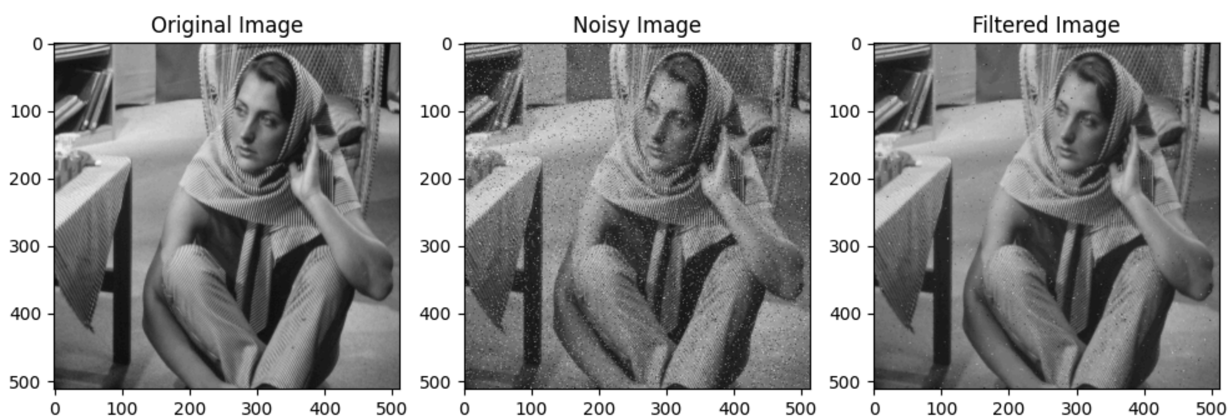
First run DRID (r=3, s=10) corruption rate = 0.05

RMSE: 32.74 %, PSNR: 17.83 dB

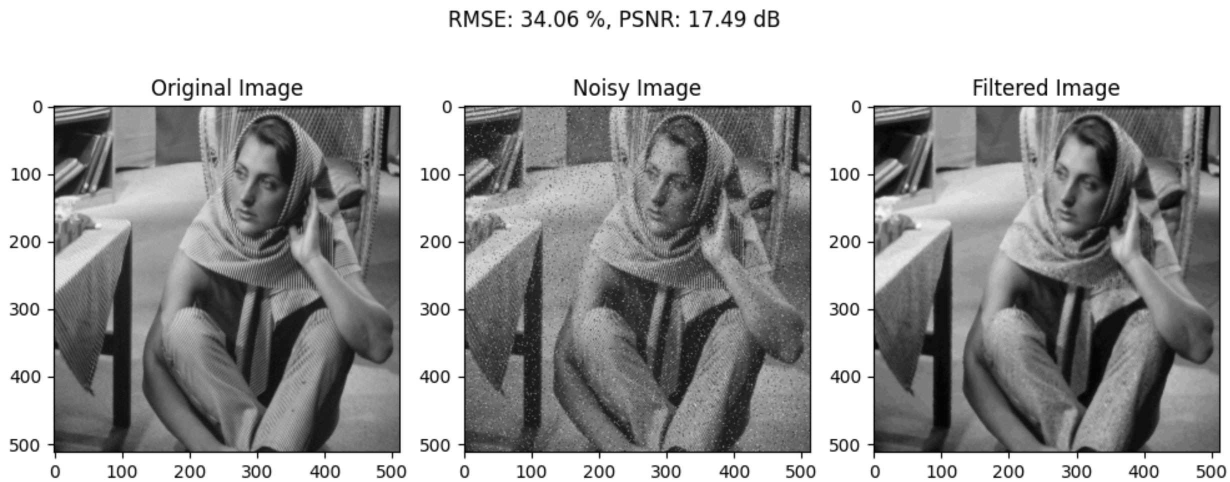


Second run DRID (r=2, s=10) corruption rate = 0.05

RMSE: 32.09 %, PSNR: 18.00 dB



Third run DRID (r=4, s=10) corruption rate = 0.05



Through iterative testing of the differential rank impulse detector I identified parameter values for R and S that optimize filtering performance. The best filtering result was achieved by selecting values of R and S that maximized PSNR and minimized RMSE. These findings indicate that the differential rank impulse detector, when fine-tuned and applied iteratively, is an effective method for reducing noise in images while preserving essential details.

I also produced a median filtering and the output images and screenshot of the run are located in the image_output directory. There are three runs, each with four subdirectories including comparison between Reg/Noisy, comparison between DRID/Noisy/Reg, comparison between Med/Noisy/Reg and screenshot of terminal output.